MULTIMEDIA UNIVERSITY

STUDENT ID NO

MULTIMEDIA UNIVERSITY

FINAL EXAMINATION

TRIMESTER 1, 2022/2023 (TERM ID 2210)

EEL4106 – HIGH VOLTAGE ENGINEERING

(LE)

07 FEBRUARY 2023
9.00 a.m – 11.00 a.m
(2 Hours)

INSTRUCTIONS TO STUDENT

1. This question paper consists of 6 pages including the cover page with 4 Questions only.

2. Answer **ALL** questions. The distribution of the marks for each question is given.

3. Please print all your answers in the Answer Booklet provided.

Question 1

(a) Voltage doubler circuit is used to generate high direct voltage, while maintaining the load current in milliamperes range. The voltage doubler consists of the rectifiers R_1 and R_2 with transformer T and capacitors C_1 and C_2 producing an output voltage 2V is shown in Figure Q1(a). Draw a complete voltage doubler circuit to produce further voltage doubling to 6V. [5 marks]

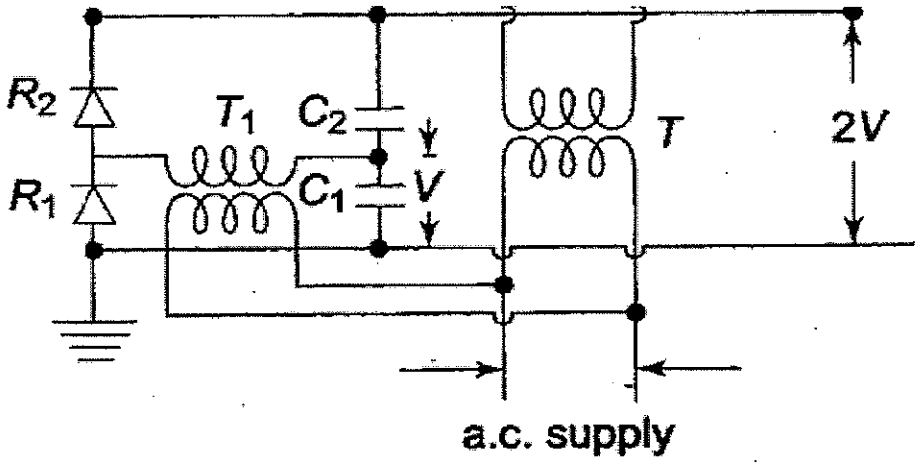

Figure Q1(a)

(b) Three winding transformers having voltage ratings of 330 V/450 kV/380 V each are cascaded to obtain 1200 kV output voltage. Calculate the resulting short circuit reactances of the cascaded transformer if the short circuit reactance of each transformer is given as: $X_{ps} = 5\%$; $X_{pt} = 6\%$; $X_{st} = 5\%$. [3 marks]

(c) List out **THREE** advantages of resonant transformer [3 marks]

(d) With an appropriate sketch of a voltage trace, define the front and tail times of a lightning impulse wave. [4 marks]

(e) A 10-stage impulse generator has 0.126 μF capacitors. The wave front and the wave tail resistances are 1000 Ω and 10000 Ω, respectively. If the load capacitor is 1500 pF, find the front and tail times of the impulse wave produced. In order to generate a typical lightning impulse, calculate the front and tail resistances that should be altered to. [10 marks]

Continued...

Question 2

(a) List any **THREE** methods of measuring High DC Voltages. [3 marks]

(b) Sphere gaps have limited range with uniform electric field where much research work has been progressed in producing the gaps with uniform electric field. List out **TWO** advantages and **TWO** disadvantages of uniform field electrode gaps. [4 marks]

(c) Determine the breakdown voltage for uniform field gap with the air gap of length 3.0 mm under uniform field and standard atmospheric conditions. [3 marks]

(d) A generating voltmeter has to be designed so that it can have a range from 30 kV to 270 kV. If the indicating meter reads a minimum current of 2.5 μA and maximum current of 30 μA, calculate the capacitance of the generating voltmeter and briefly discuss whether the calculated value of the capacitance is acceptable. Assume that the driving motor is a synchronous motor with a speed of 1500 rpm. [3 marks]

(e) A 33 kV, 50 Hz Schering Bridge is used to test a sheet of bakelite. It has a standard compressed air capacitor, Cs of 104 pF, a non-inductive variable resistor, R3 of 400 Ω, a non-inductive resistor, R4 of 160 Ω in parallel with a variable capacitance, C4 of 0.25 μF. Using a series equivalent circuit, calculate the following for the bakelite sheet;

(i) the resistance, [2 marks]
(ii) the capacitance, [2 marks]
(iii) the loss factor [3 marks]

(f) Resistive dividers are preferred for the measurement of steep impulse voltage of not too long a duration. List out **TWO** main drawbacks of the resistive divider. [2 marks]

(g) Choose the correct answer:

(i) '*As a routine test the cable is subjected to a voltage 2.5 times the working voltage for 10 min without damaging the insulation of the cable.*' Define the type of test for this method.

(a) Partial discharge test
(b) Dielectric dissipation factor test
(c) Power frequency and DC withstand voltage test
(d) Impulse withstand voltage test

[1 mark]

Continued...

(ii) '*Insulator is subjected to standard impulse of 1.2/50 μs of specified value under dry conditions with both impulse polarities. If five consecutive applications do not cause any flash over or puncture, the insulator is deemed to have passed the test.*' Define the type of test for this method.
(a) Wet flash over and 1-minute rain test
(b) Impulse withstand test
(c) Dry flashover and dry 1-minute test
(d) 50% dry impulse flashover test

[1 mark]

(iii) Standard switching impulse test is done on transformers having normal voltage level of 300 kV or more. What is the standard switching impulse used for the test.
(a) 300/3000 μs
(b) 250/2500 μs
(c) 1.2/50 μs
(d) 50/500 μs

[1 mark]

Question 3

(a) Insulating liquids are expected to give very high dielectric strength of the order of 10 MV/cm, where having high dielectric strength and dielectric constant are important to the insulating liquids. List out **THREE** more important properties of insulating liquids. [3 marks]

(b) Briefly describe the differences between the 'pure' and 'commercial' liquids. [3 marks]

(c) Current-field characteristic curve for a hydrocarbon liquid is shown in Figure Q3(c). The curve has three distinct regions. Briefly explain on these three regions. [6 marks]

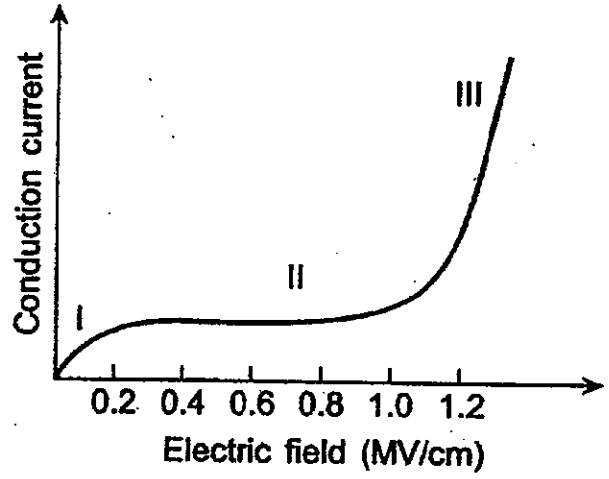

Figure Q3(c)

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(d) The mechanism of breakdown is a complex phenomenon, varies depending on the time of applied voltage. Figure Q3(d) shows the breakdown voltage, V_B versus the times of applied voltage curve for various principles of breakdown mechanisms in solid dielectric. Define the principles of breakdown mechanisms for labels A, B, C and D. [4 marks]

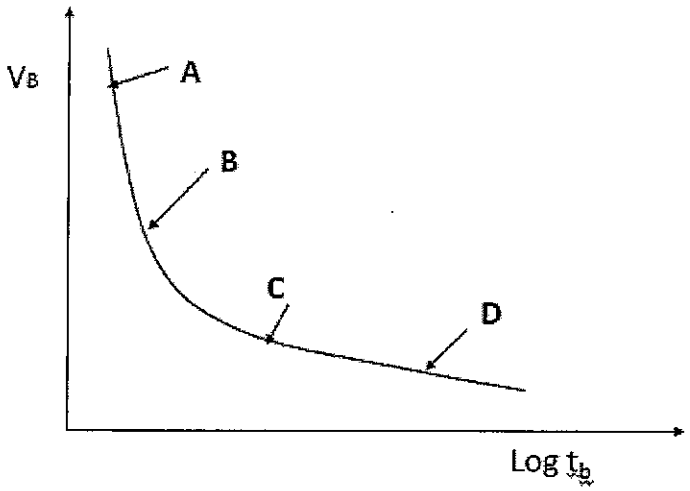

Figure Q3(d)

(e) A solid insulating block of thickness 1.3 cm and having a dielectric constant of 5 is subjected to a 50-Hz AC voltage. The specimen contains an air void of thickness 1.5 mm. Considering the breakdown strength of air as 30 kV/cm (peak), calculate;

(i) the maximum voltage which can be applied across the specimen without any internal discharge. [5 marks]

(ii) the thickness of the dielectric material compressed to, *d*, when this dielectric material is subjected to electrostatic compressive forces, causing mechanical instability to occur. [2 marks]

(f) The spreading of spark channels during 'tracking' in a solid dielectric, in the form of branches of a tree is called 'treeing', which normally occurs after a prolonged operation. List out **TWO** methods to prevent the 'treeing'. [2 marks]

Question 4

(a) Overvoltages occurring in the power system can be classified as transient and power frequency overvoltages. Transient overvoltages are caused by lightning and switching. Opening of a circuit breaker to clear a fault is one of the causes of electrical switching in power systems. List out **THREE** other causes of switching overvoltages. [3 marks]

(b) Briefly describe the difference between self-restoring and non-self-restoring insulation. [4 marks]

Continued...

(c) Sketch a typical impulse voltage waveform indicating clearly the statistical and formative time lags. Provide definitions of statistical and formative time lags. [4+4 marks]

(d) The duty of overvoltage protection is to ensure the transients arriving at an installation from the power lines or originating in the installation itself are reduced to a level bearing a definite relationship to the rated voltage of the network. One of the oldest known means of providing protection against overvoltages, and is still in use to some extent is the spark gap. Provide **THREE** main drawbacks of this spark gap. [3 marks]

(e) Tables Q4(e)(i) and Q4(e)(ii) show the results obtained respectively for string insulator and arcing horn. Answer the following questions;

(i) Can the arcing horn protect the string insulator I against destructive discharges? Provide your reasons. [1+2 marks]

(ii) If the flashover voltage of the arcing horn I is reduced by 20% while maintaining the same time to flashover, is the volt-time curve of arc-horn I suitable for insulation coordination for the string insulator I? Provide your reasons. [1+3 marks]

Table Q4(e)(i)

Voltage Level (kV)	1200	1500	2100	2700	2800	2800	2900
Time to Flash (μs)	35	30	20	15	10	5	2

Table Q4(e)(ii)

Voltage Level (kV)	1100	1780	2700	3000	3200	3300	3400
Time to Flash (μs)	35	30	20	15	10	5	2

End of the Paper.